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ESTIMATION OF SEA WAVE HEIGHT IN TOAYA COASTAL WATERS, CENTRAL SULAWESI

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ABSTRACT

Introduction: Toaya is one of the villages located in Sindue District, Donggala Regency, which along the village is located in the coastal area of the high seas. Donggala Regency is the oldest port city in Central Sulawesi Province, whose territory has a long coastal area of 400 km. The waves that occur in the ocean are mainly caused by the influence of the wind. **Method**: This study aims to obtain wave heights that occur at Toaya Beach and can predict waves that occur with a return period of the next few years period (2, 5, 10, 25, 50, 100) years using the Gumbel Method and Fisher Typpet-Type 1 Method. **Results and Discussion**: Results of the analysis found that the significant wave height (Hs) = 1.65 m and the significant wave period (Ts) = 7.05 seconds in 2013 in the northwest direction. For the analysis of the frequency distribution using the Gumbel method at a return period of 2 years = 1.45 m, at a return period of 5 years = 1.59 m, at a return period of 10 years = 1.69 m, at a return period of 25 years = 1.80 m, at the return period of 50 years = 1.89 m and at the return period of 100 years = 1.98 m while the frequency distribution analysis using the Fisher Tippet Type-1 method at the return period of 2 years = 1.45 m, at the return period of 5 years = 1.56 m, at a return period of 10 years = 1.63 m, at a return period of 25 years = 1.72 m, at a return period of 50 years = 1.79 m and at a return period of 100 years = 1.86 m. **Conclusion**: From the results of the discussion and analysis carried out, it can be concluded that from the UA value obtained from 2009 – 2018 and the data fetch at the research location, it is obtained that the significant wave height value and the maximum significant wave period in 2013 in the northwest direction are Hs = 1.65 m and Ts = 7.05 seconds.

1. Introduction

Indonesia is one of the regions of Southeast Asia, most of which is a marine area. Around 80% of the Indonesian people are fishermen who depend on the marine commodity industry for their livelihoods [1]. However, Indonesia is vulnerable to sea-level rise, earthquakes, and tsunamis [2]–[4]. Coastal areas in the Central Sulawesi Region have many uses, including tourist attractions, fishing villages, pond areas, state roads, and so on. Therefore, coastal areas need to be protected from the risk of damage and the danger of abrasion/erosion and sedimentation at river mouths [5].

Ocean waves are an up and down movement of seawater without being accompanied by a mass transfer of water. The ocean waves have dimensions in the form of wave period (T), wavelength, wave height, and wave speed [6]. The ocean waves are a phenomenon of periodic rising and falling of water that can be found in almost all places in the world. Toaya is one of the villages located in

Sindue District, Donggala Regency, which along the village is located in the coastal area of the high seas. Donggala Regency is the oldest port city in Central Sulawesi Province, whose territory has a long coastal area of 400 km. The waves that occur in the ocean are mainly caused by the influence of the wind. The occurrence of waves is caused by stress from the wind acting on the sea surface. So, if the wind strength is large, the waves that occur are also large [7]. The wind over the ocean transfers its energy to the waters, causing ripples, hills, and turning into what we call waves [8]. Information about wind and waves is the most important part that affects various types of activities at sea [9].

According to [10], waves caused by wind are an important part of coastal and marine areas. Ocean wave information can be obtained by conducting field measurements, but it costs a lot because it requires equipment, mastery of technology, measurements in the long term, and the field is not easy. With the existence of sufficient wind data to forecast waves with a certain return period for both the short and long term, optimal, economic and efficient planning results will be obtained [11]. In predicting wave height based on wind data, three parameters are needed, namely: wind speed (u), the length of the area affected by the wind (Fetch area (F)), the length of the wind blowing (wind duration (t)) and a map of the study area [12]. The purpose of this study was to analyze a certain return period, namely, the wave height using the Gumbel Method and the Fisher Tippet-Type 1 Method in Toaya Coastal Waters, Sindue District, Donggala Regency.

The purpose of this study was to determine the significant wave height (Hs) and significant wave period (Ts) that occurred on Toaya Beach and to obtain the wave height that occurred at Toaya Beach and be able to predict waves that occurred with a return period in the next few years period (2, 5, 10, 25, 50, 100) years.

2. Method

2. 1 Data collection

The data used in this study is secondary data which is the result of measurements and records obtained from the ECMWF (European Center for Medium-range Weather Forecast). The data needed are:

1. Wind Data

The wind data in this paper were collected based on hourly wind data obtained from ECMWF data for ten years of observation, namely 2009 - 2018.

2. Fetch data

The data fetch is the length of the wave forming region.

3. Thematic Maps

Thematic Map is a map of the earth (.dwg file) that is used to calculate the fetch wave generation area.

2.2 Data Management

At the data processing stage, after all, supporting data has been obtained, it is then processed to obtain the desired parameters for research results.

1. Wind Data Management

Collect hourly wind data for ten years. With the wind data for these hours, it will be possible to know the wind with the daily average wind speed. Then the data is processed and can be presented in the form of a wind rose so that the wind characteristics on Toaya Beach can be read quickly. Based on wind data obtained from wind data measurements carried out on land. Therefore, it is necessary to transform from wind data over land closest to the study location to wind data above sea level.

2. Wave Data Management

Wind data for ten years to forecast waves so as to produce the height and period of deep-sea waves. As for wave forecasting, the wind data on land is transformed into wind data at sea; then, the wind stress factor is given with the fetching price. From the value of the voltage and the fetching price, the wave height and period of the wave are found by using a wave forecasting chart. The data taken were used to determine the type of waves at the research site using the Gumbel Method and the Fisher Tippet-Type 1 Method.

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2.3 Data Analysis

The writing process starts from the study of literature, data collection. Then it is processed so that the value of significant wave height (Hs) and significant wave period (Ts) is obtained, analysis of the frequency of ocean waves with a return period using the Gumbel Method and Fisher Tippet-Type 1. After analyzing the data processing, the results and discussion, and conclusions will be obtained. It can be seen in full in Fig 1, 2, and 3 below.

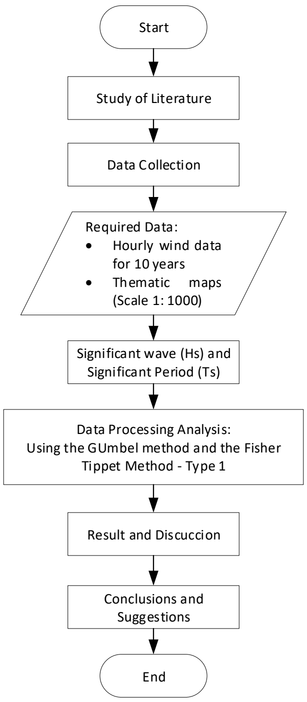

Fig 1. Research Flowchart

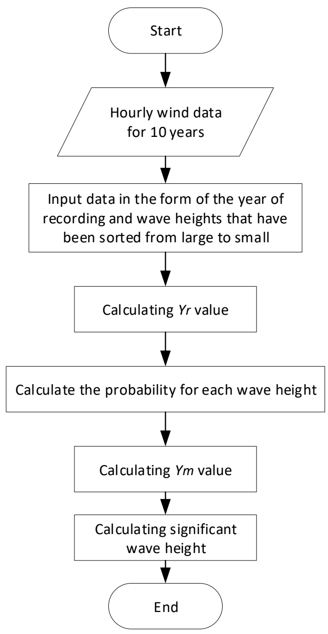

Fig 2. Flowchart Data Processing Using Fisher Tippet-Type 1 Method

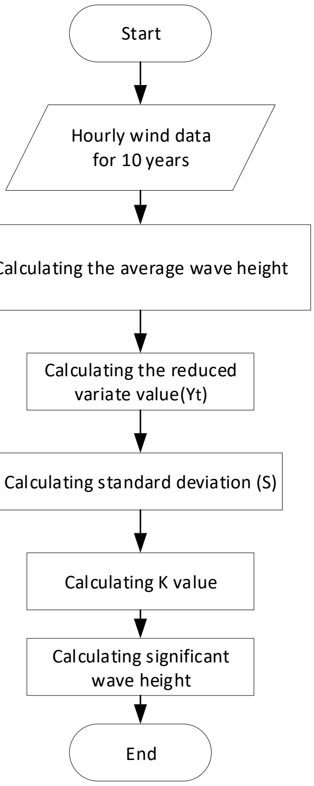

Fig 3. Flowchart Data Processing With Gumbel Method

3. Results and Discussion

Data entered in the WRPLOT application and worksheets (spreadsheets). This data contains the year, month, date, hour, wind direction, and wind speed. Determine the direction of the wind in the form of symbols. The wind data required are wind direction and speed data. The data is obtained from ECMWF, namely from 2009-2018.

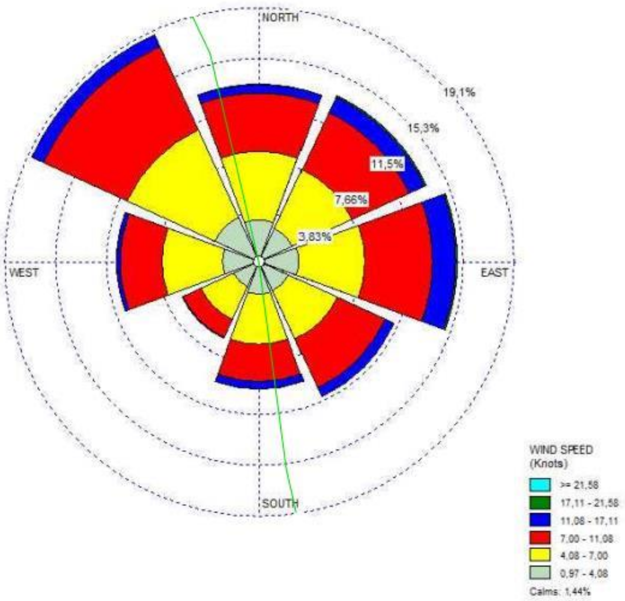

Fig 4. Windrose 10 Years (2009-2018)

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Calculation of Length Xi (Length of fetch) from different directions possible can be seen in Table 1.

Direction	**Corner**	***Xi* (m)**	**a**	**cos a**	***Xi*·cos a**	***Feff* (m)**
Nort	340	4057	-20	0,940	3812	680
	345	2226	-15	0,966	2150	
	350	-	-10	0,985	-	
	355	-	-5	0,996	-	
	0	-	0	1,000	-	
	5	-	5	0,996	-	
	10	-	10	0,985	-	
	15	-	15	0,966	-	
	20	-	20	0,940	-	
South	160	-	-20	0,940	-	10330
	165	-	-15	0,966	-	
	170	-	-10	0,985	-	
	175	23474	-5	0,996	23385	
	180	19165	0	1,000	19165	
	185	14584	5	0,996	14529	
	190	12350	10	0,985	12162	
	195	11764	15	0,966	11363	
	200	10663	20	0,940	10020	
Southwest	205	9801	-20	0,940	9210	200000
	210	9333	-15	0,966	9015	
	215	15352	-10	0,985	15119	
	220	188990	-5	0,996	188271	
	225	4990486	0	1,000	4990486	
	230	248233	5	0,996	247288	
	235	2408200	10	0,985	2371614	
	240	2125647	15	0,966	2053217	
	245	11591	20	0,940	10892	
West	250	2034318	-20	0,940	1911634	200000
	255	1888793	-15	0,966	1824434	
	260	1549237	-10	0,985	1525701	
	265	1264584	-5	0,996	1259772	
	270	258566	0	1,000	258566	
	275	244456	5	0,996	243526	
	280	267133	10	0,985	263075	
	285	265864	15	0,966	256805	
	290	271932	20	0,940	255532	
	295	270948	-20	0,940	254608	
	300	269629	-15	0,966	260442	
	305	268365	-10	0,985	264288	
	310	262121	-5	0,996	261124	

Northwest	315	221001	0	1,000	221001	200000
	320	204609	5	0,996	203830	
	325	191778	10	0,985	188864	
	330	193397	15	0,966	186807	
	335	504769	20	0,940	474328	

The results of wave analysis between observational data and secondary data using the Gumbel Method and the Fisher Tippet-Type 1 method did not show a significant difference. The data used to compare the wave height between the Gumbel Method and the Fisher Tippet-Type 1 method are observational data and secondary data. The accuracy of Gumbel's Method and Fisher's Tippet-Type 1 method was calculated using the Root Mean Square (RMSE). As shown in Table 2 and Table 3 below:

Table 2. Gumbel Method RMSE Calculation Results

Direction	Gumbel Method		
	Observation Data (Yi) (m)	Prediction Data (Yi) (m)	(Yi-Yi)² (m)
Nort	1,25	0,08	1,37
Nort	1,25	0,09	1,34
Nort	1,25	0,10	1,32
Nort	1,25	0,11	1,30
Nort	1,25	0,12	1,28
Nort	1,25	0,13	1,27
			7,87
1,146 m			

Table 3. RMSE Calculation Results in Fisher Tippet-Type 1 . Method

Direction	Fisher Tippet-Type 1 Methods		
	Observation Data (Yi) (m)	Prediction Data (Yi) (m)	(Yi-Yi)² (m)
Nort	1,25	0,08	1,37
Nort	1,25	0,09	1,35
Nort	1,25	0,10	1,33
Nort	1,25	0,10	1,32
Nort	1,25	0,11	1,30
Nort	1,25	0,11	1,29
			7,96
1,152 m			

From Table 2 and Table 3, it can be seen that the Gumbel method obtained an RMSE value of 1.146 m while the Fisher Tippet-Type 1 method obtained an RMSE value of 1.152 m. The results obtained indicate that the Gumbel method is more accurate.

4. Conclusion

From the results of the discussion and analysis carried out, it can be concluded that from the UA value obtained from 2009 – 2018 and the data fetch at the research location. It is obtained that the significant wave height value and the maximum significant wave period in 2013 in the northwest direction are Hs = 1.65 m and Ts = 7.05 seconds. Predict the recurrence wave that occurs, the Gumbel method and the Fisher Tippet-Type 1 method are used. So that the following values are obtained For the Gumbel method, the highest return period value is in the northwest direction, namely two years = 1.45 m, for a five year return period = 1.59 m, for a ten year return period = 1.69 m, for a 25 year return period = 1 .80 m, at the return period of 50 years = 1.89 m and at the return period of 100 years = 1.98 m and For the Fisher Tippet-Type 1 method, the highest return period value is in the northwest direction, namely two years = 1.45 m, in the five year return period = 1.56 m, in the ten year return period = 1.63 m, in the return period 25 years = 1.72 m, at a return period of 50 years = 1.79 m and at a return period of 100 years = 1.86 m.

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